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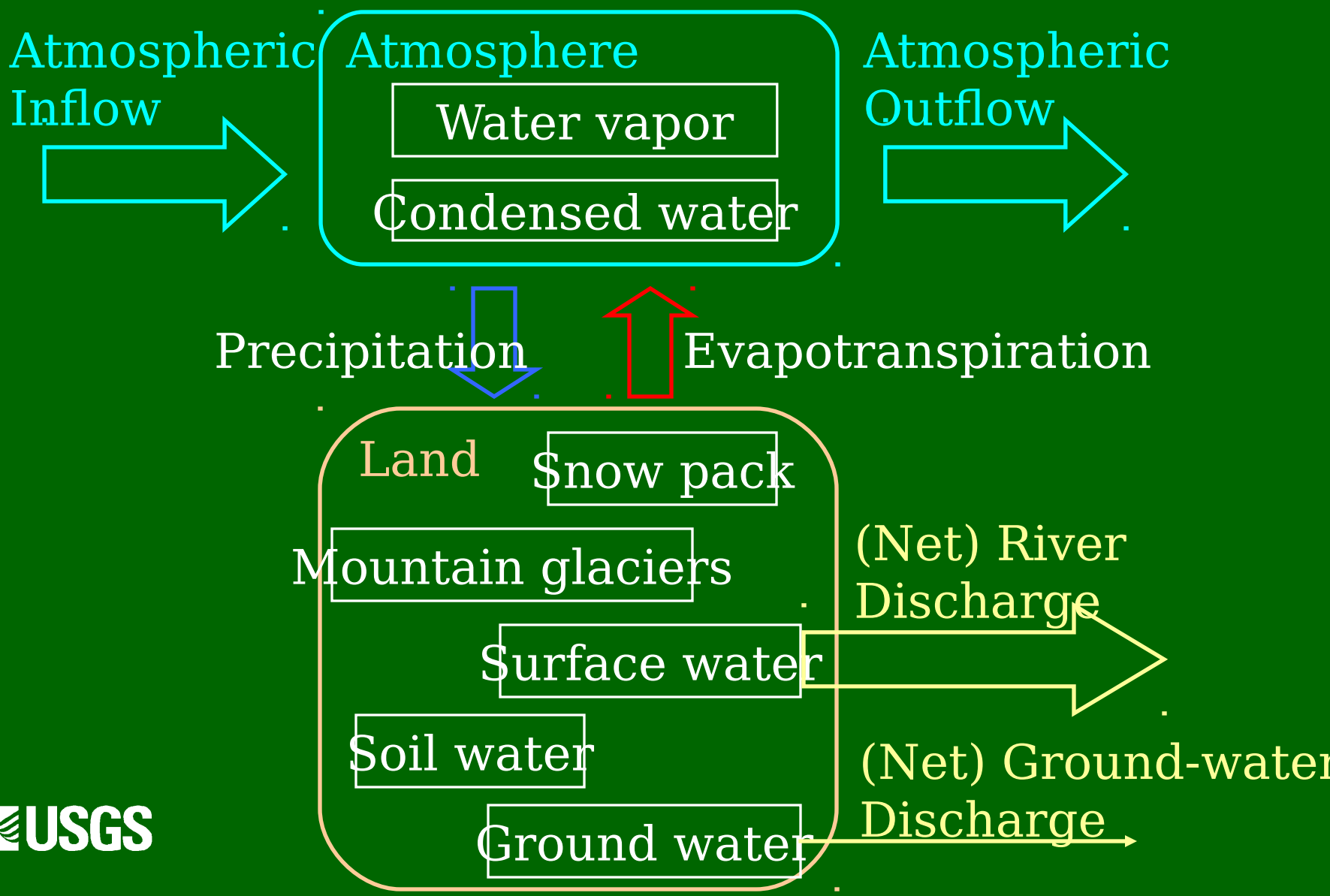
Manifestations of Climate Change in Annual-Mean Runoff and Streamflow, with a Focus on the United State

Christopher Milly, USGS

"Climate Change and Water Resources"
U.S. Army Corps of Engineers—U.S. Geological Surv
Joint Headquarters Meeting
Washington, DC
May 31, 2007

U.S. Department of the Interior
U.S. Geological Survey

Atmosphere-Land Column Water Balance



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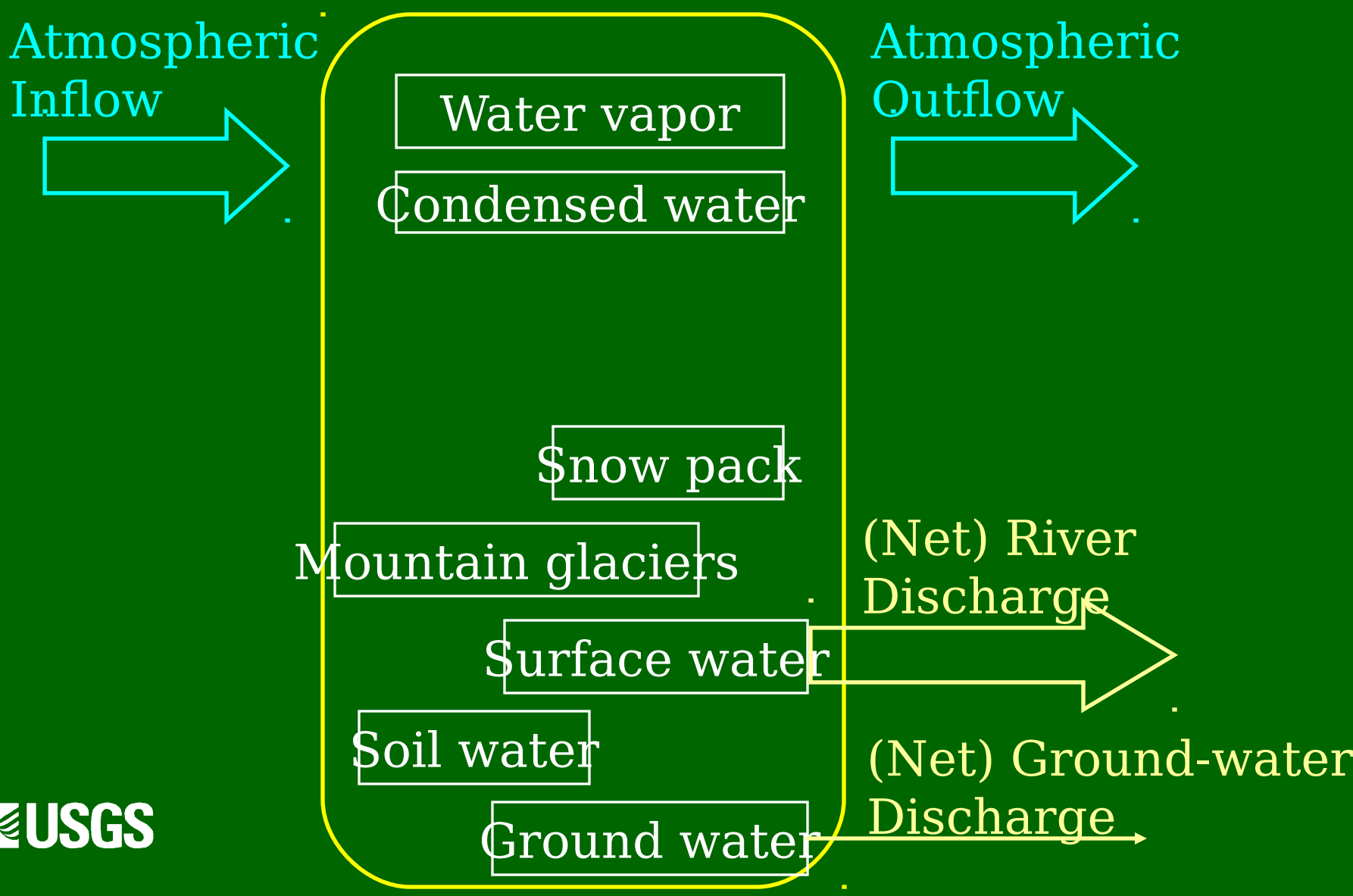
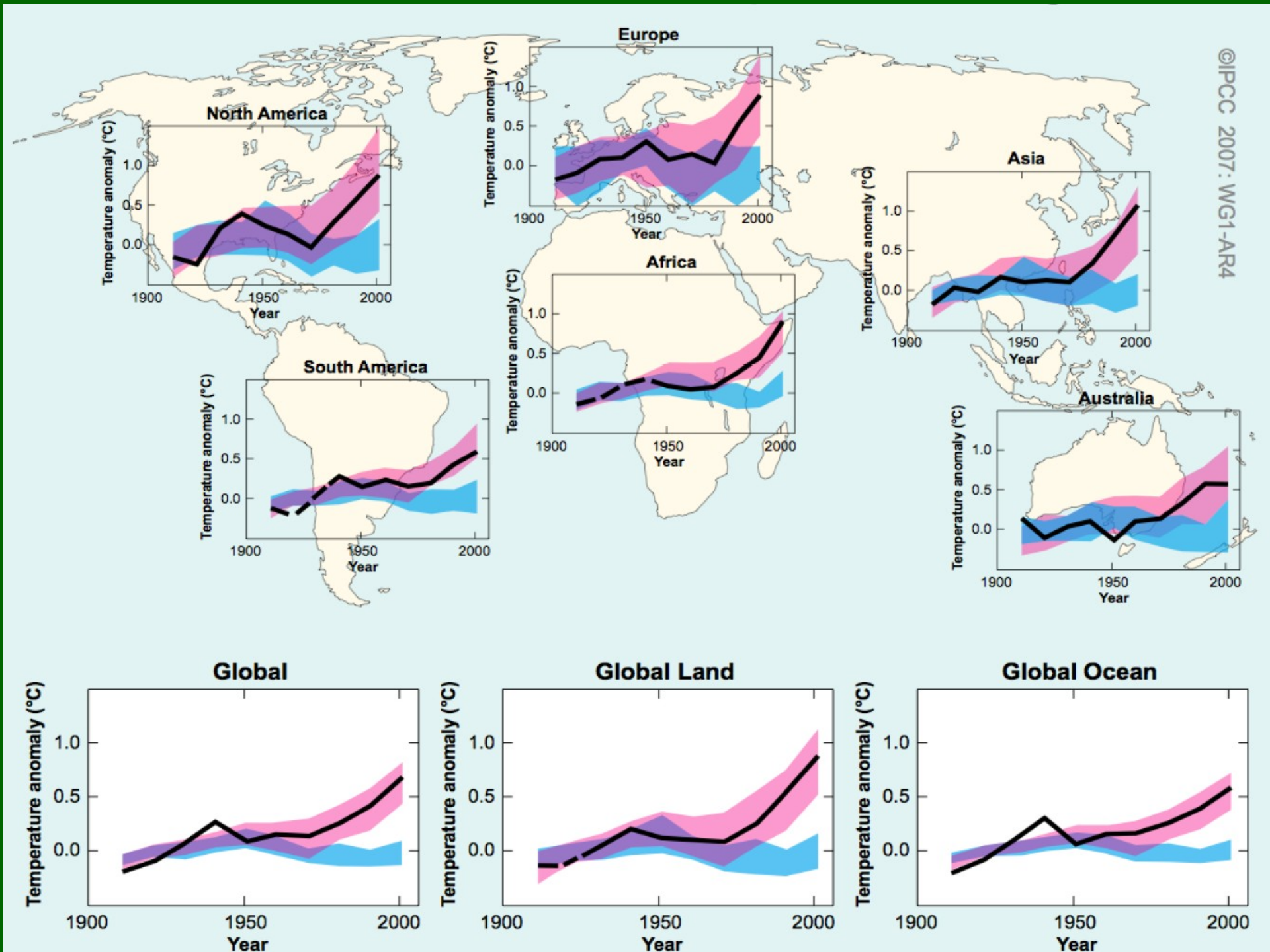
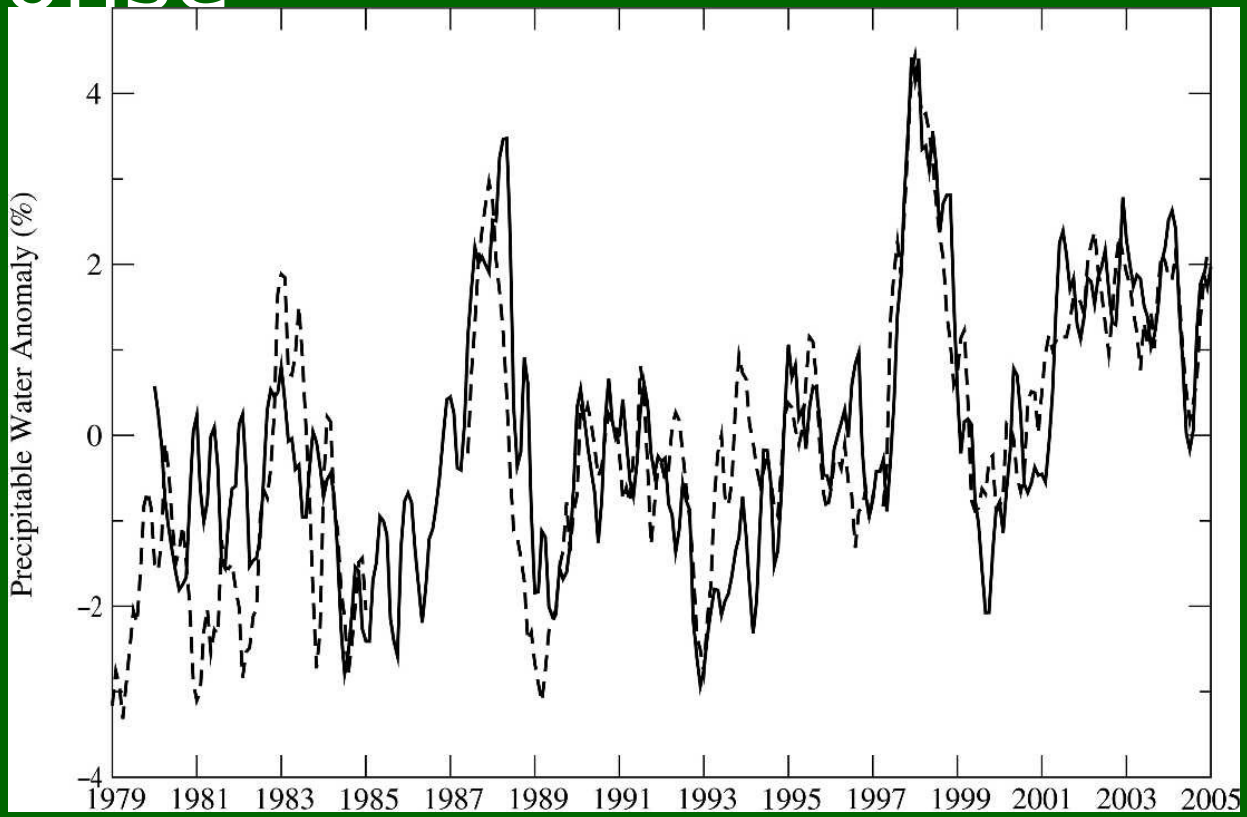
Atmosphere-Land Column Water Balance

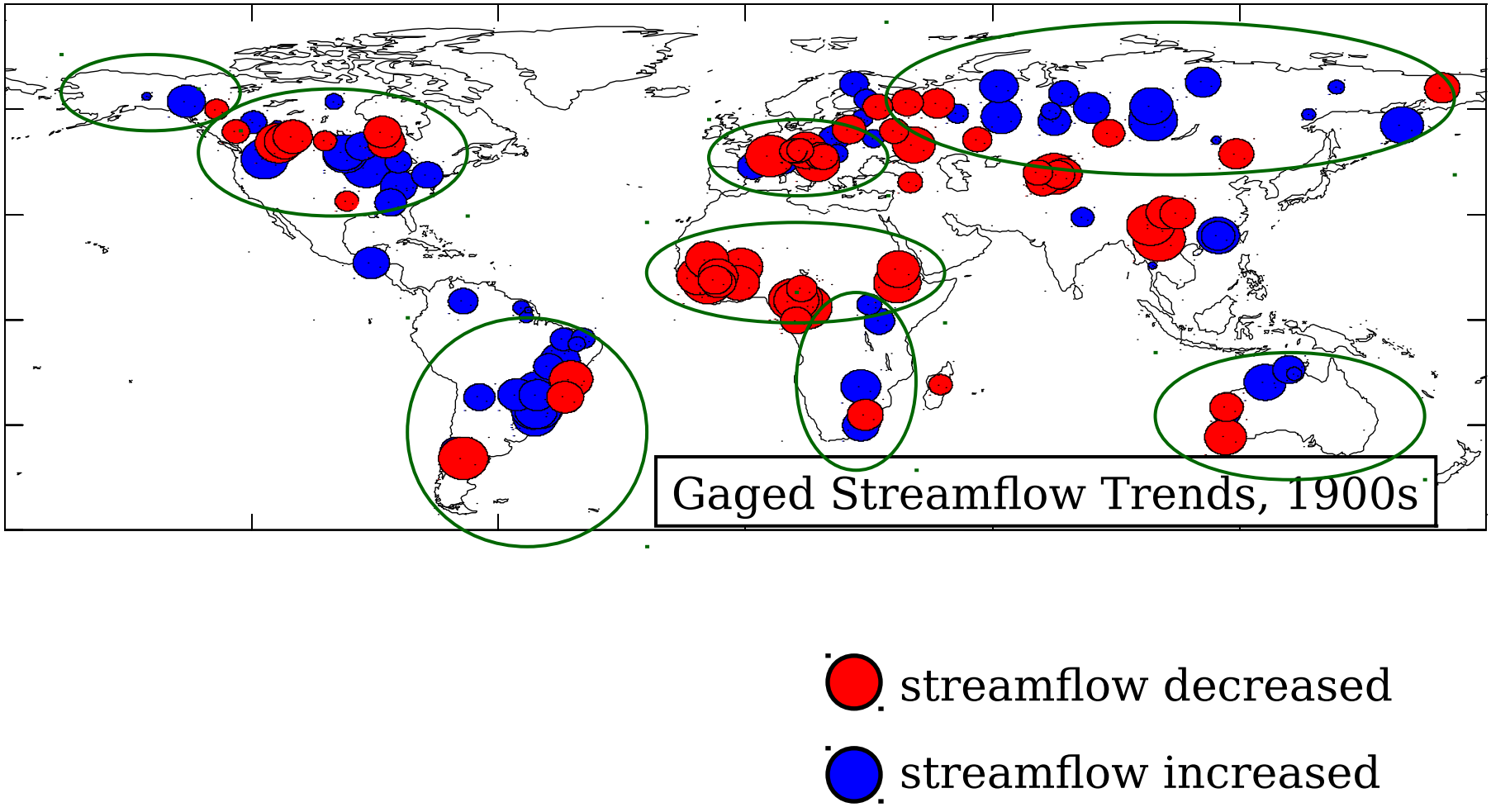


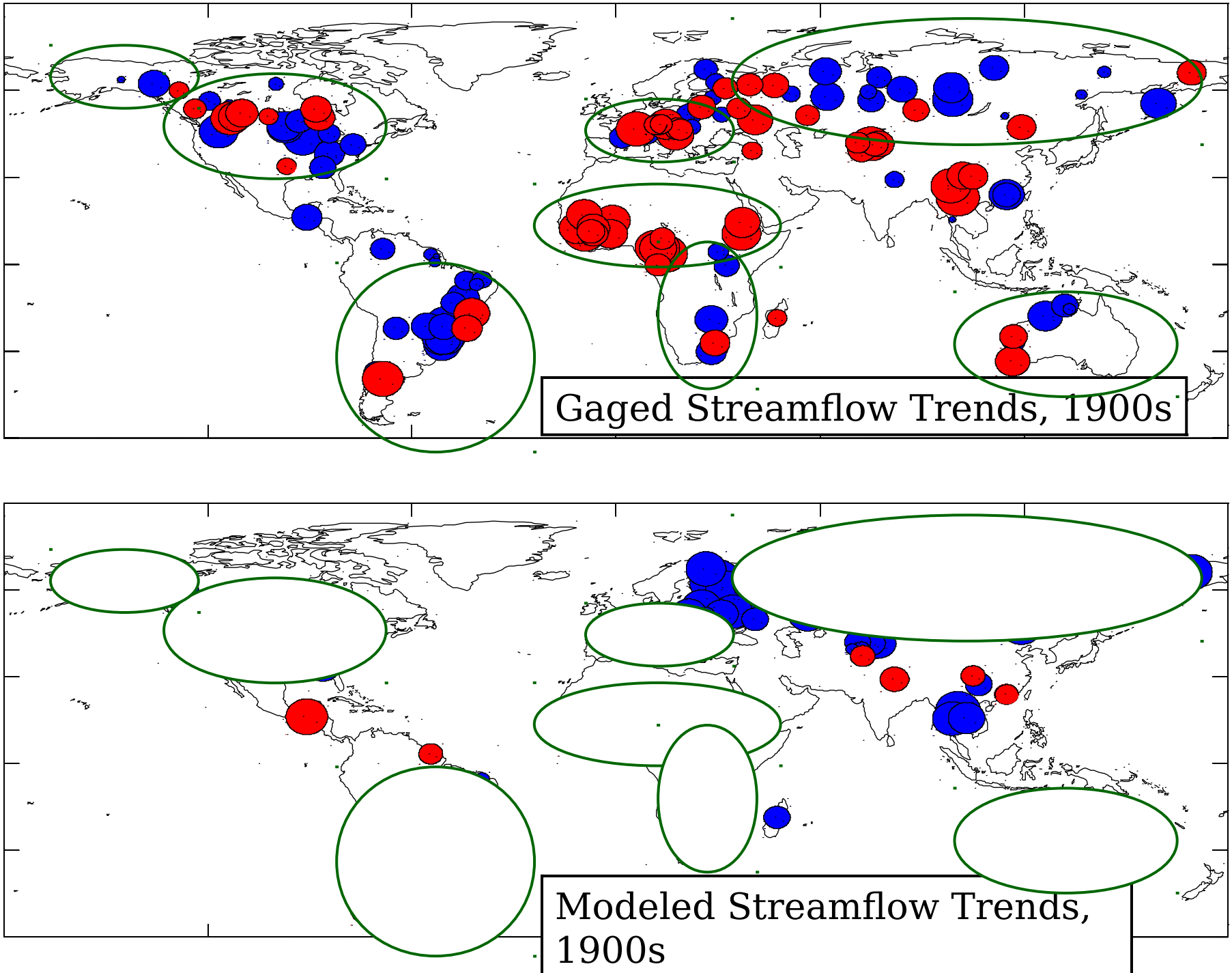

Europe
North America
Asia
Africa
South America
Australia
Global
Global Land
Global Ocean
Temperature anomaly (°C)
Year
1900
1950
2000
1.0
0.5
0.0
©IPCC 2007: WG1-AR4

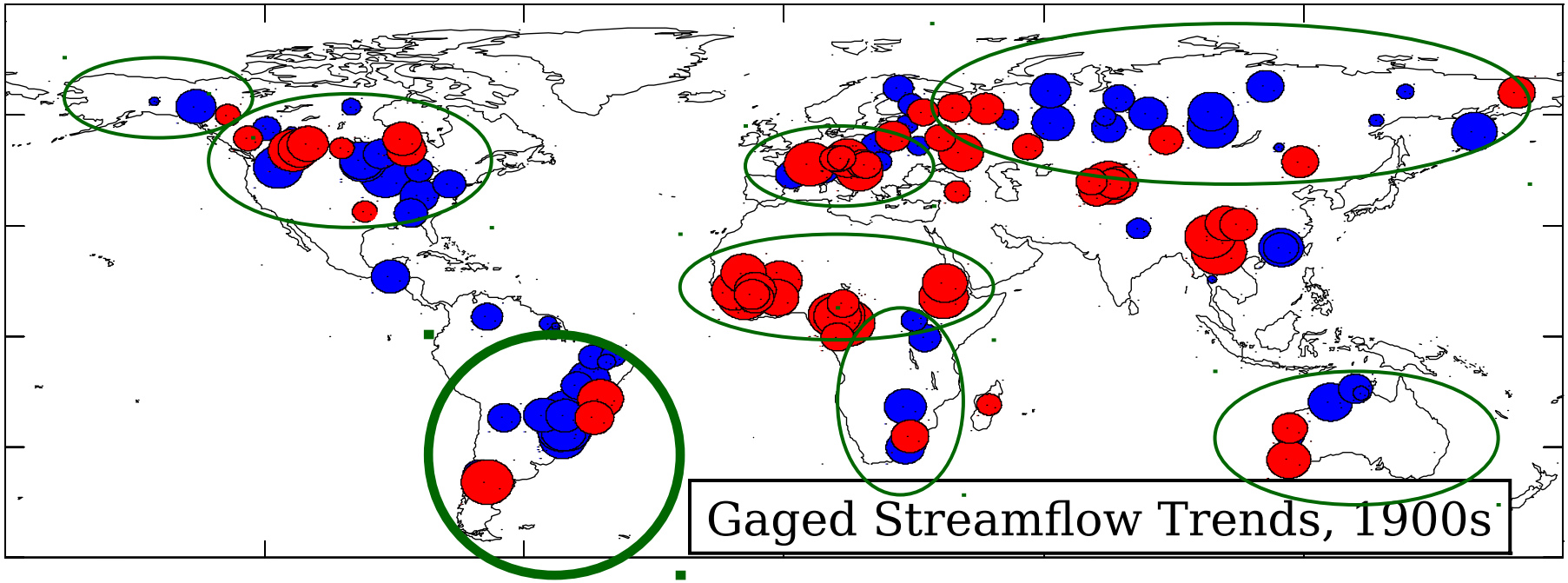
Robustness of Hydrospheric Response

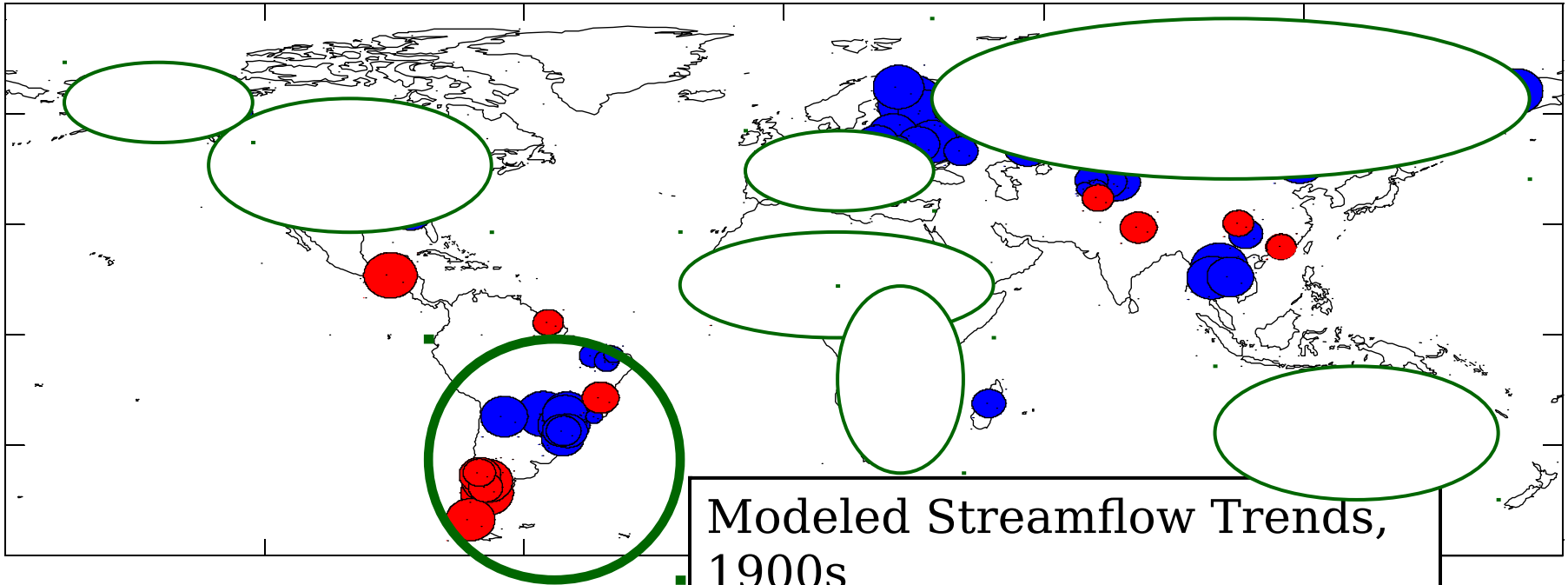


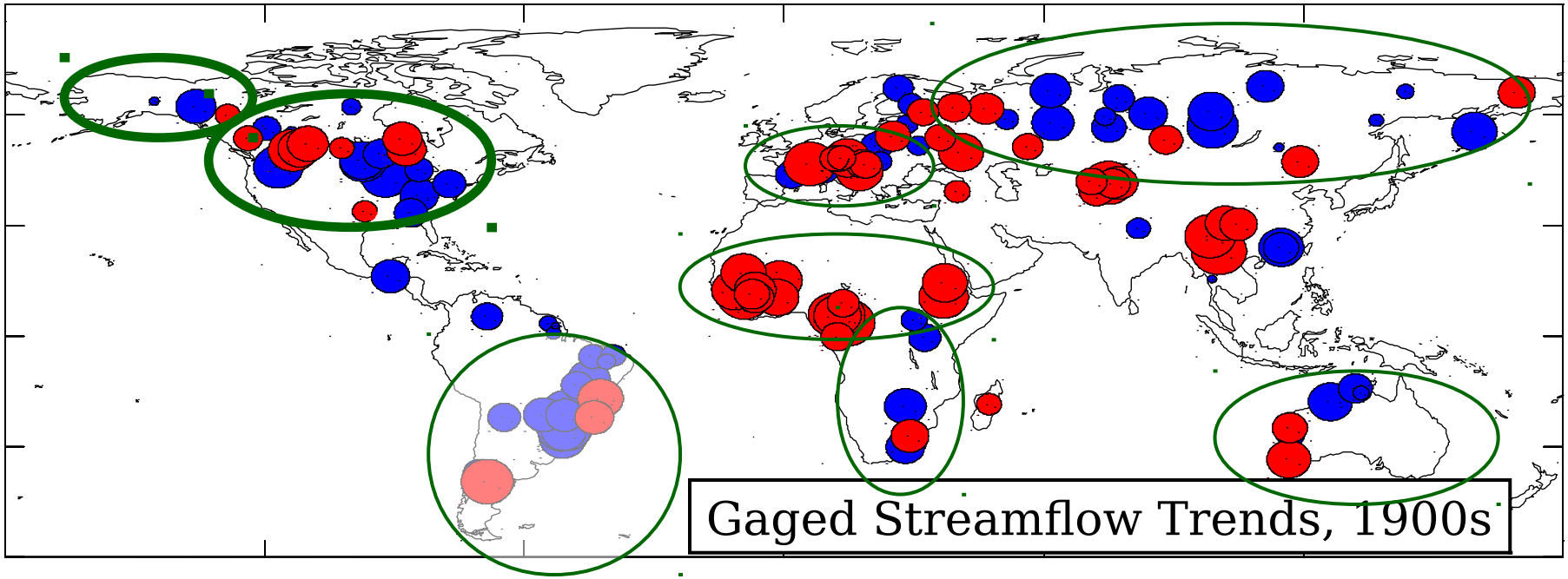
Atmospheric water content anomaly, 30S-30N over ocean; GFDL GCM; SMMR,SMM/I observations (Held and Soden, 2006)

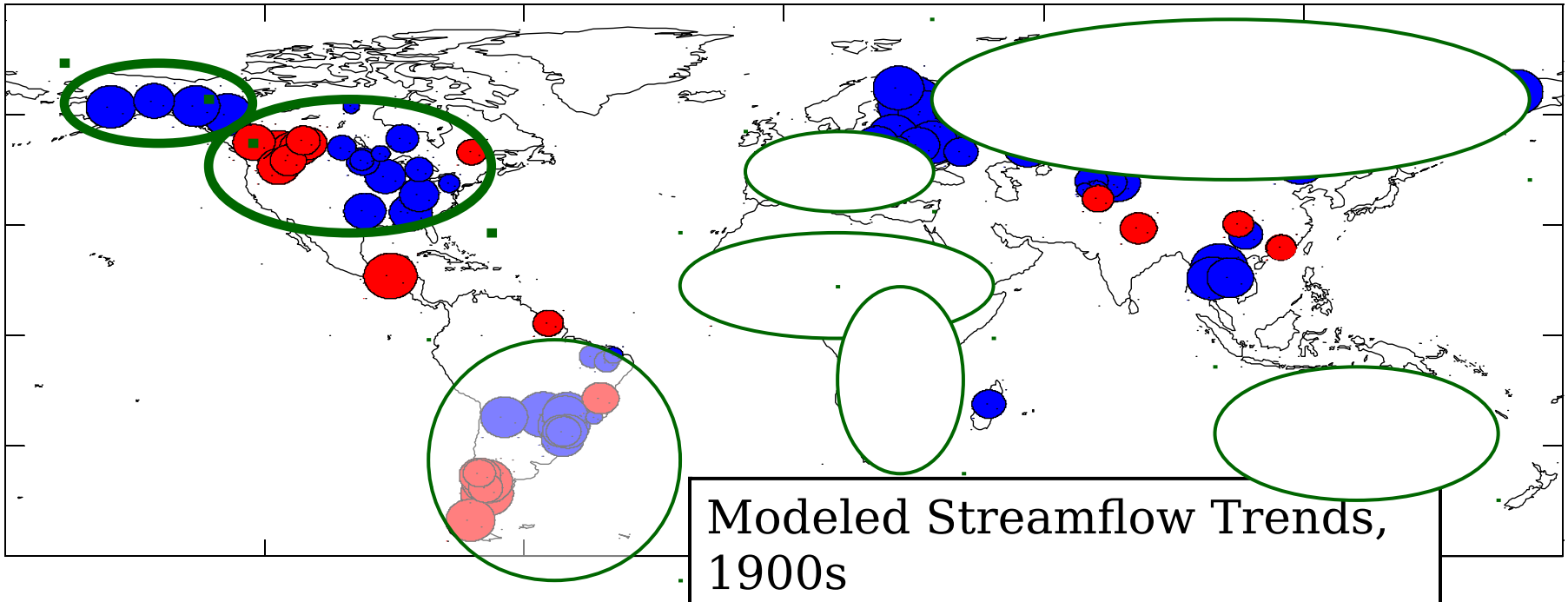

Gaged Streamflow Trends, 1900s
streamflow decreased
streamflow increased


Gaged Streamflow Trends, 1900s
Modeled Streamflow Trends, 1900s


Gaged Streamflow Trends, 1900s


Modeled Streamflow Trends, 1900s


Gaged Streamflow Trends, 1900s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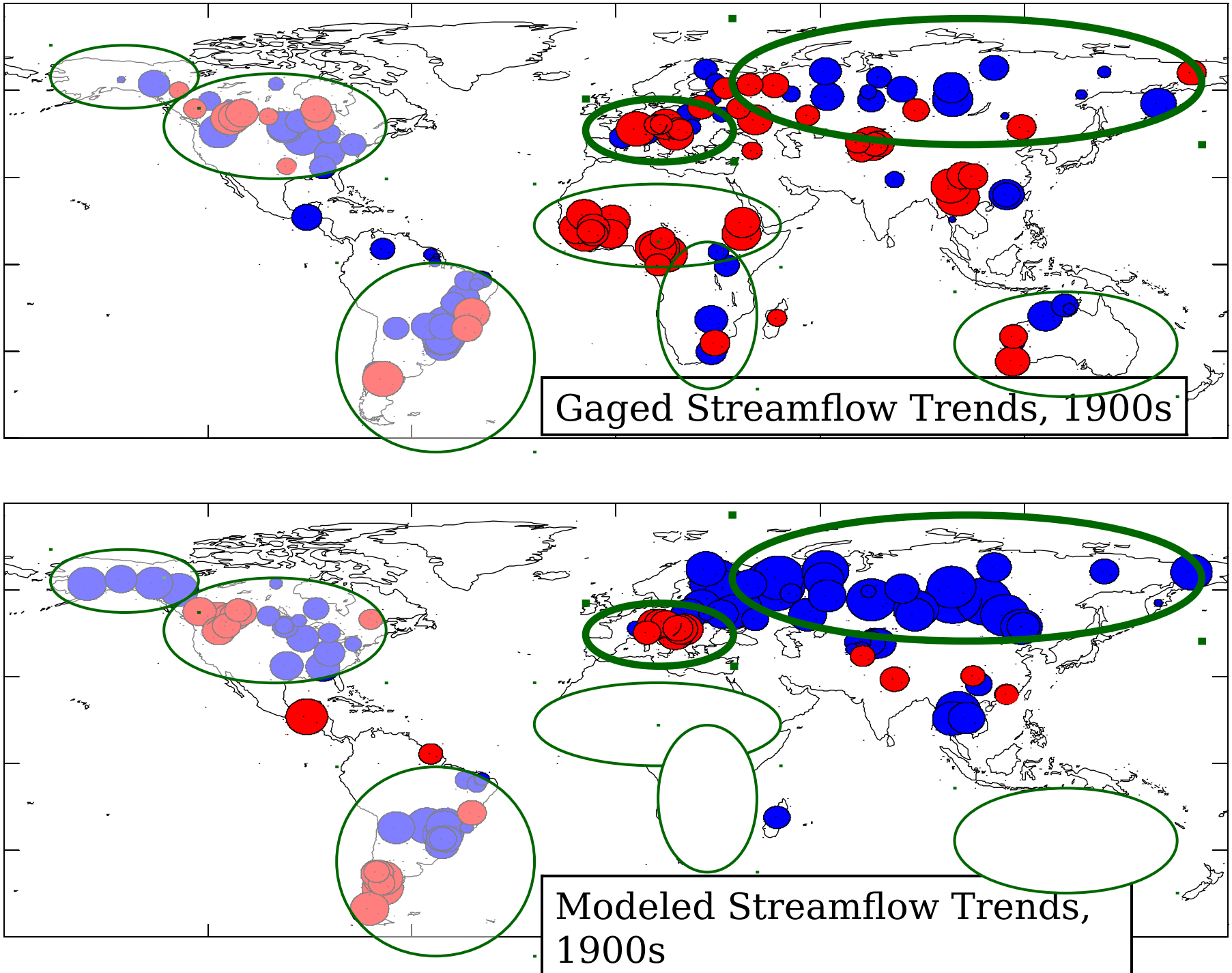
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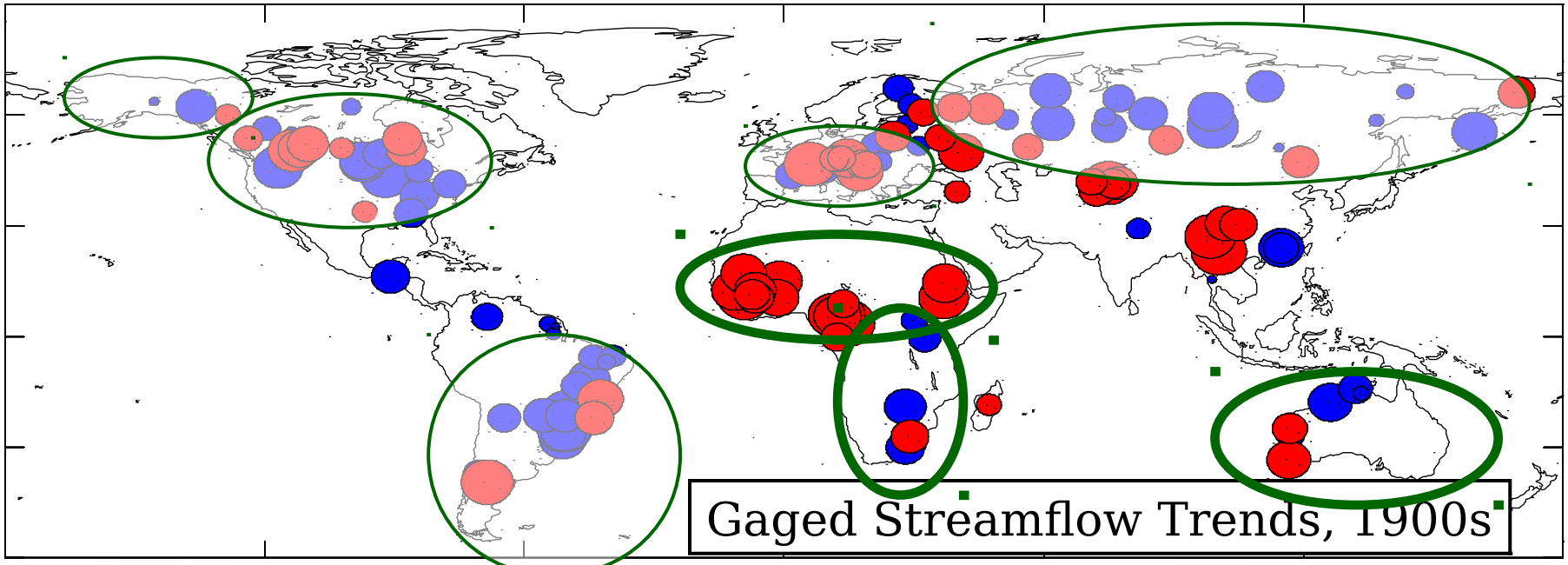
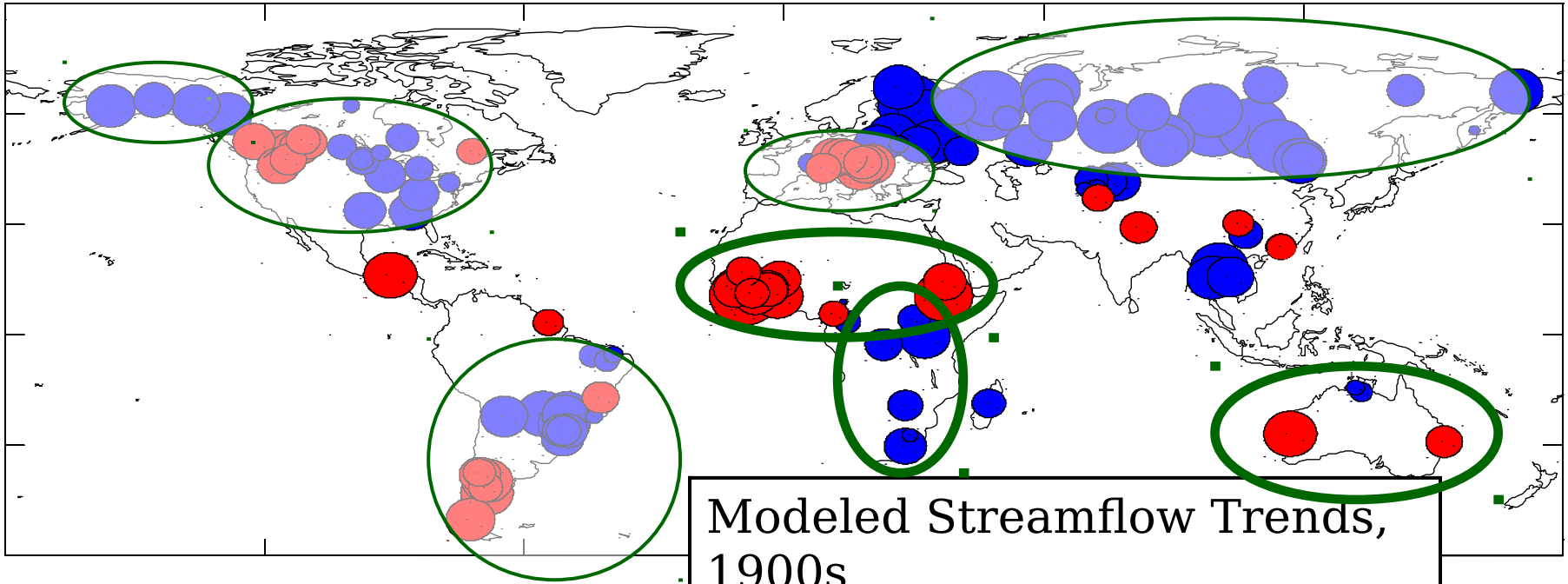
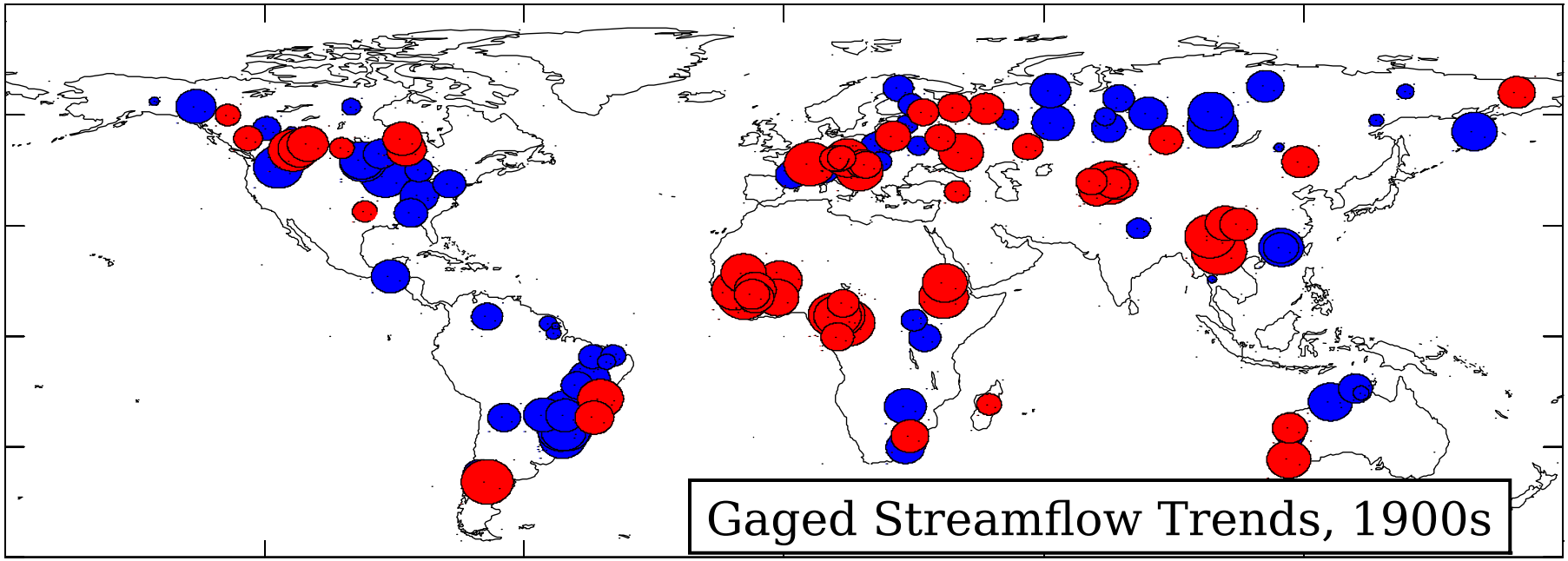
Modeled Streamflow Trends, 1900s


Gaged Streamflow Trends, 1900s


Modeled Streamflow Trends, 1900s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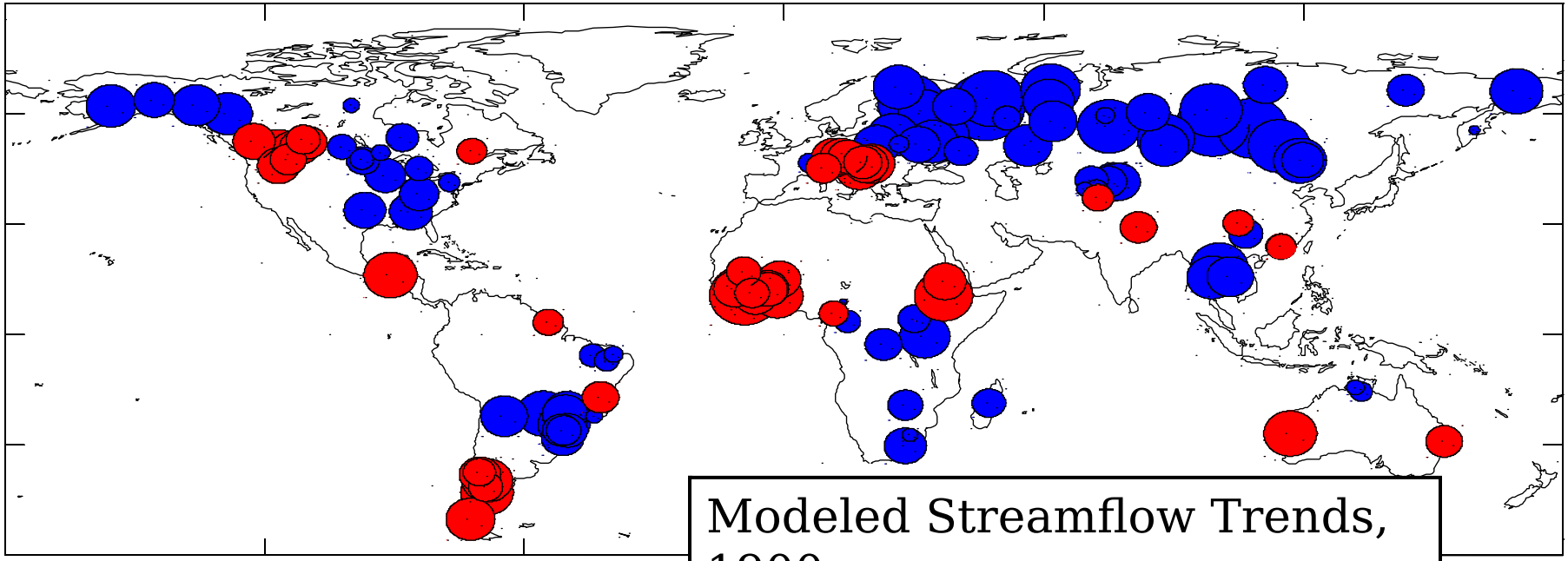
Modeled Streamflow Trends, 1900s

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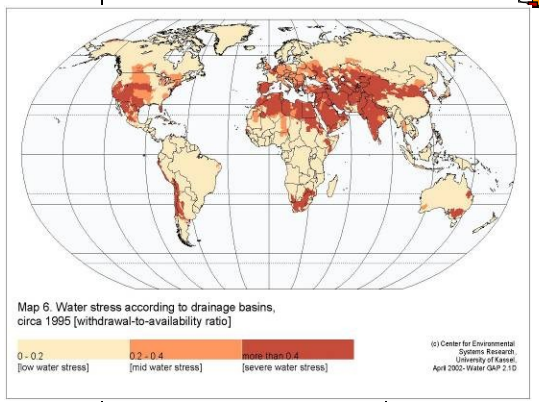
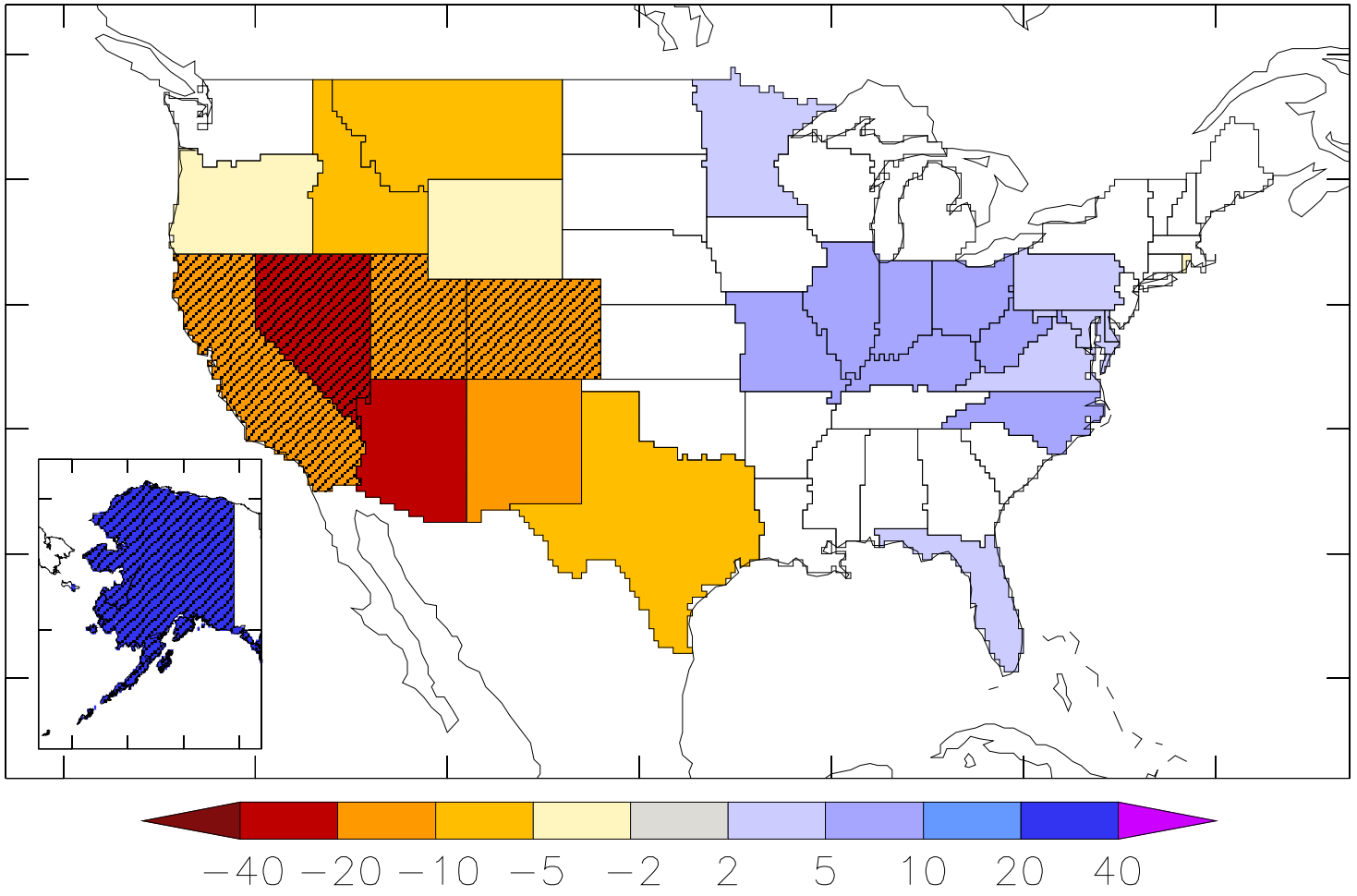
It now appears likely that a substantial part of global streamflow variability during the 20th century was not a random internal fluctuation of the climate system, but rather was caused by externally forced changes in climate.


Map 6. Water stress according to drainage basins,
circa 1995 [withdrawal-to-availability ratio]
0 - 0.2
[low water stress]
0.2 - 0.4
[mid water stress]
more than 0.4
[severe water stress]
(c) Center for Environmental Systems Research, University of Kassel, April 2002 - Water GAP 2.1D

−40 −20 −10 −5 −2 2 5 10 20 40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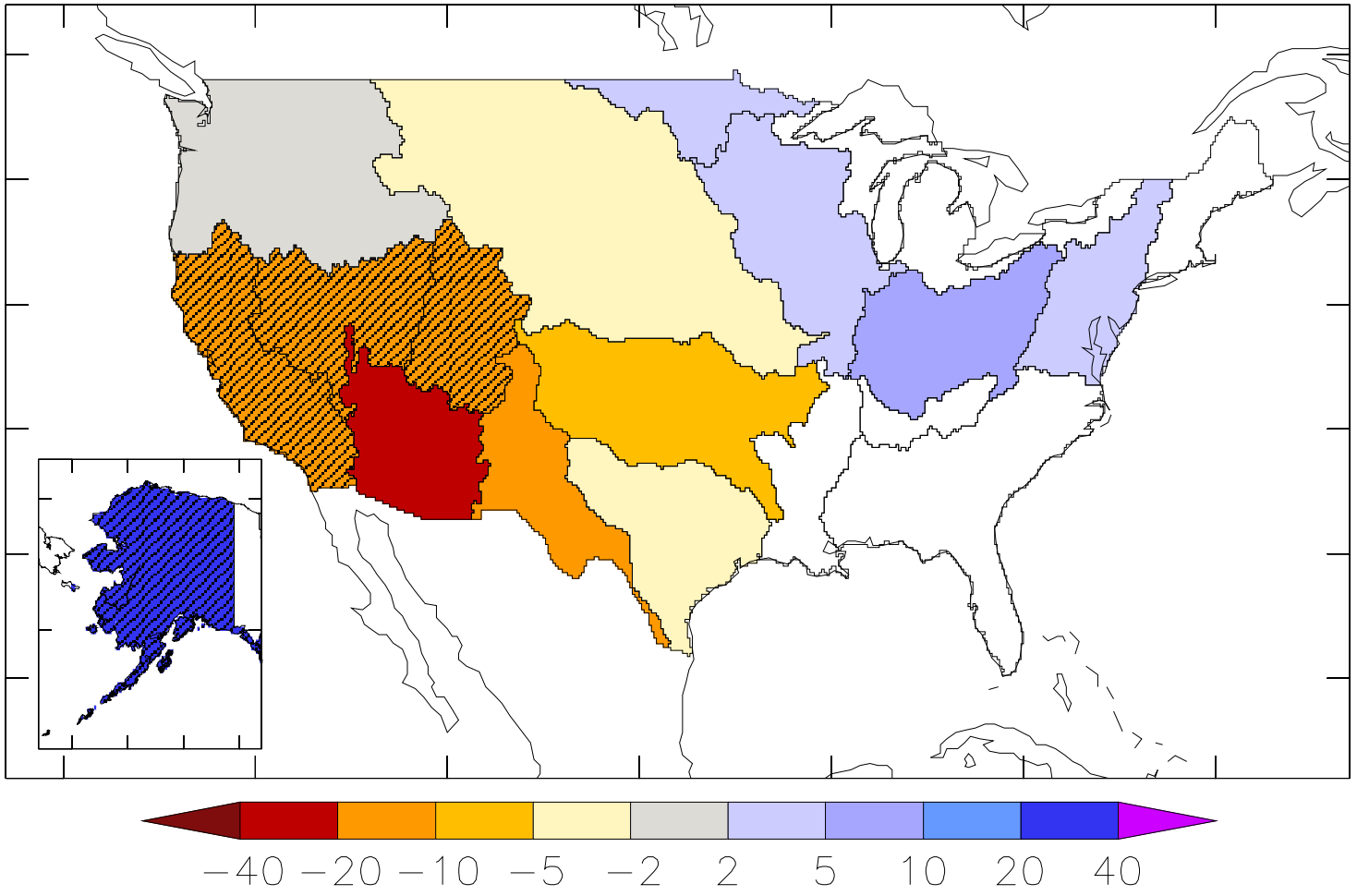
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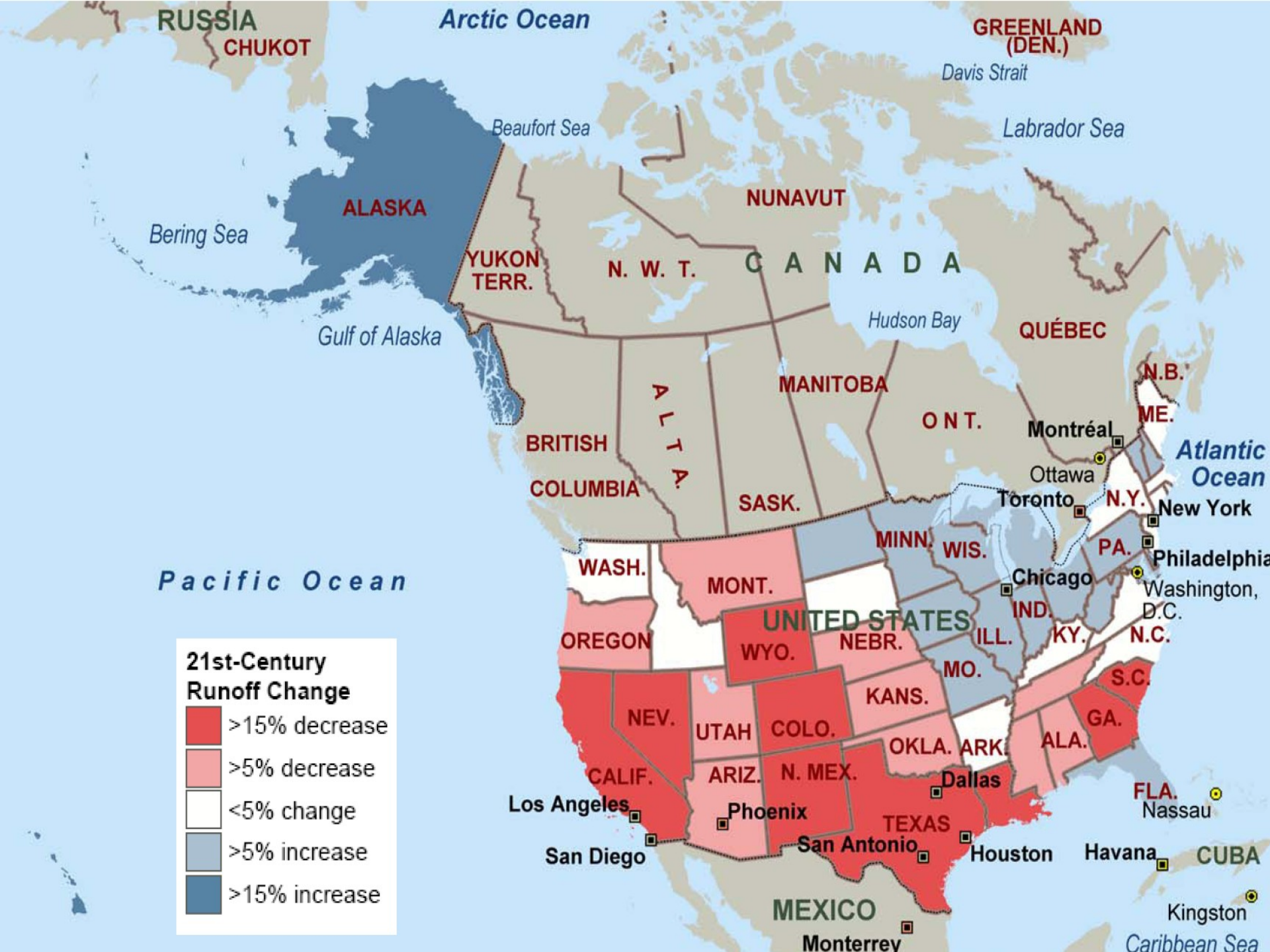
RUSSIA
CHUKOT
Arctic Ocean
GREENLAND (DEN.)
Davis Strait
Beaufort Sea
Labrador Sea
ALASKA
Bering Sea
NUNAVUT
YUKON TERR.
N. W. T.
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Hudson Bay
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Chicago
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IND.
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OREGON
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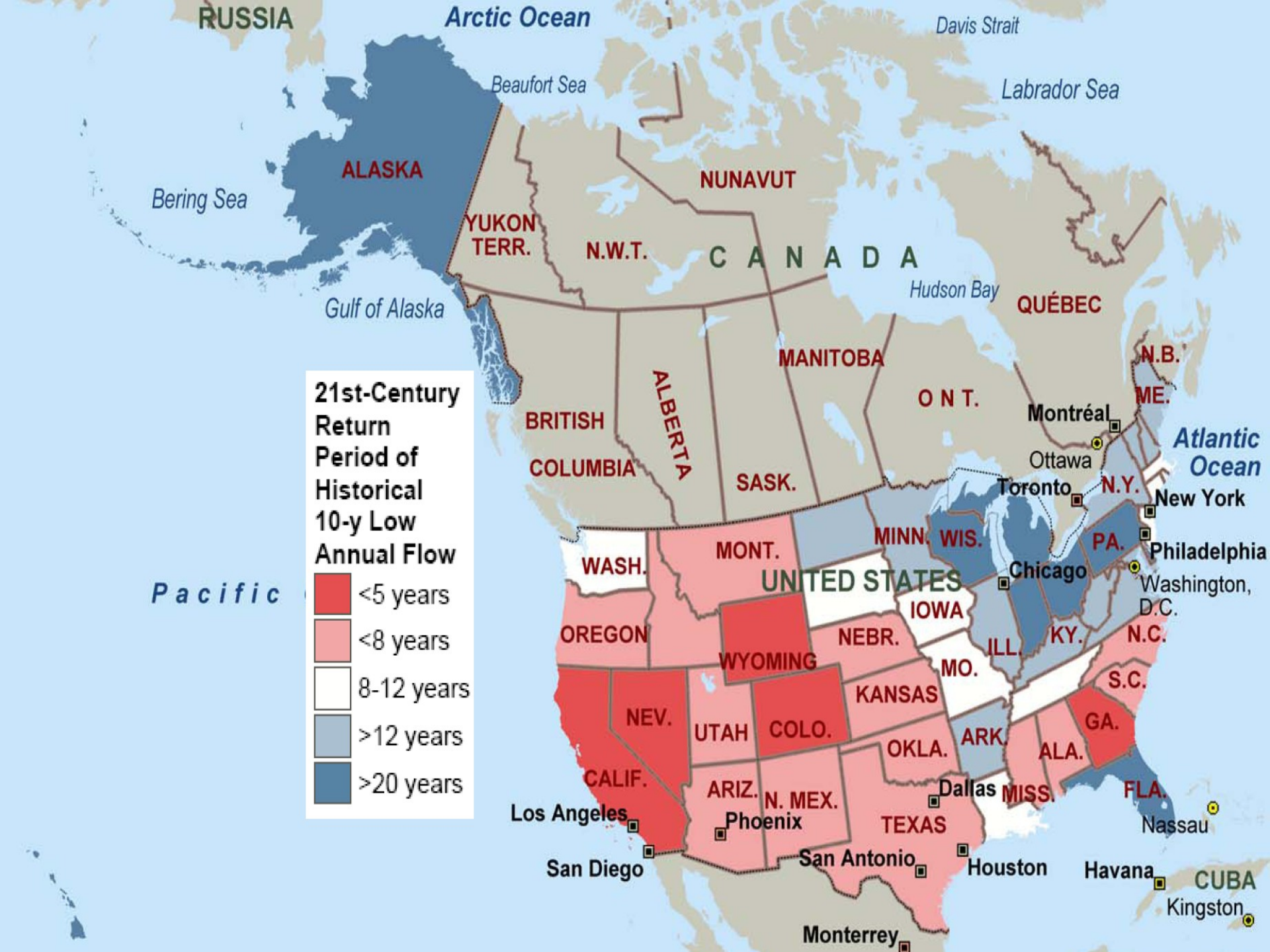
Dallas
FLA.
Nassau
Los Angeles
Phoenix
TEXAS
San Antonio
Houston
Havana
CUBA
San Diego
MEXICO
Kingston
Monterrey
Caribbean Sea
Pacific Ocean
21st-Century Runoff Change
>15% decrease
>5% decrease
<5% change
>5% increase
>15% increase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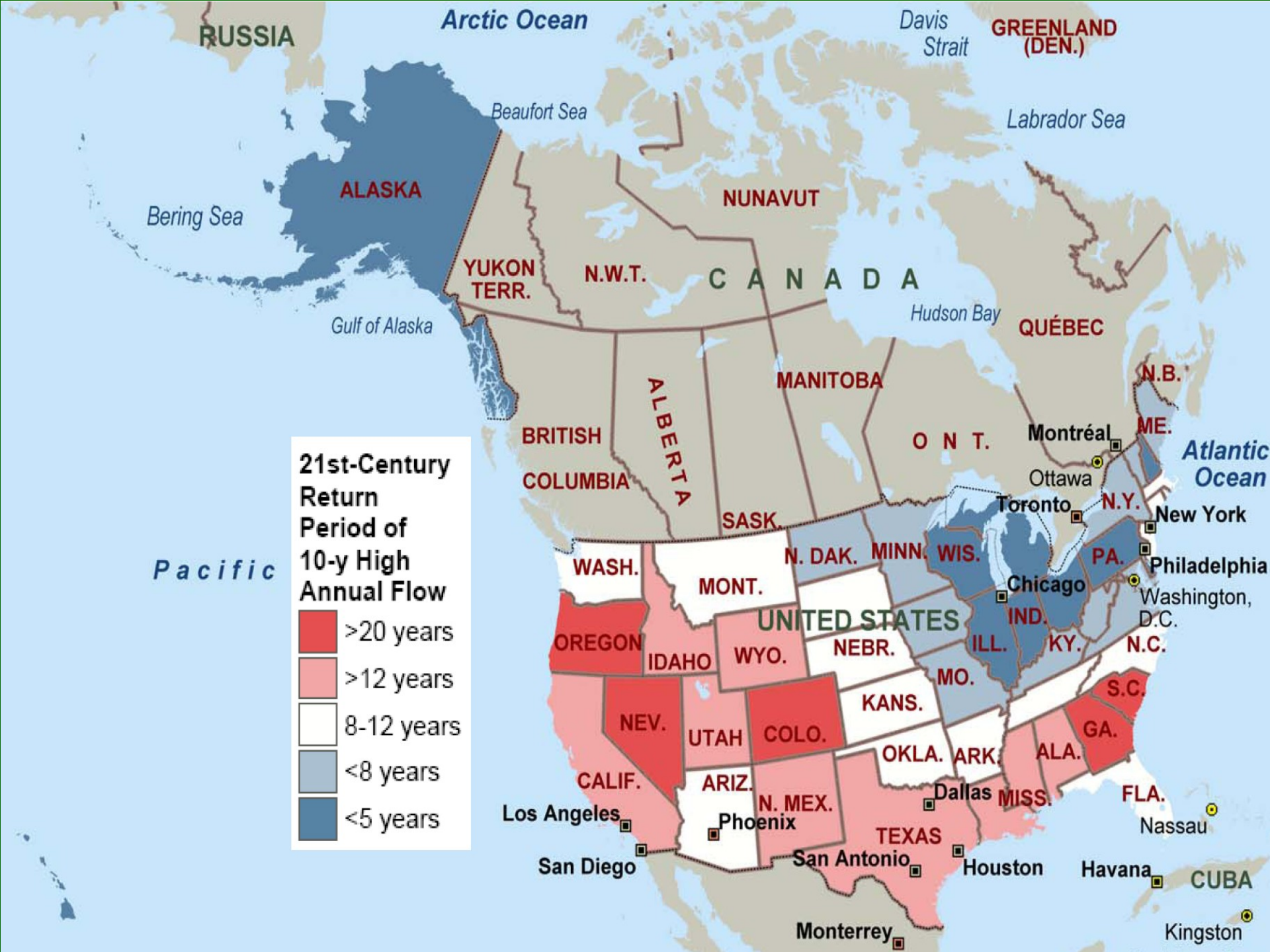
Houston
San Diego
Havana
CUBA
Kingston
Monterrey
21st-Century Return Period of Historical 10-y Low Annual Flow
<5 years
<8 years
8-12 years
>12 years
>20 years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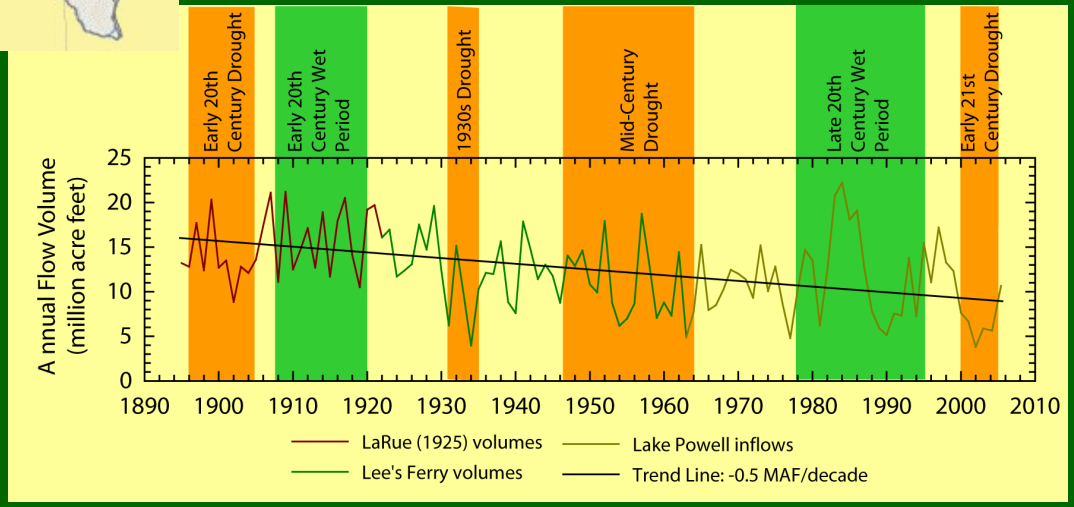
Kingston
Pacific
21st-Century Return Period of 10-y High Annual Flow
>20 years
>12 years
8-12 years
<8 years
<5 years

Changes in Annual Runoff

Colorado River at Lee's Ferry

USGS Fact Sheet 2004-3062,
Version 2, August 2004



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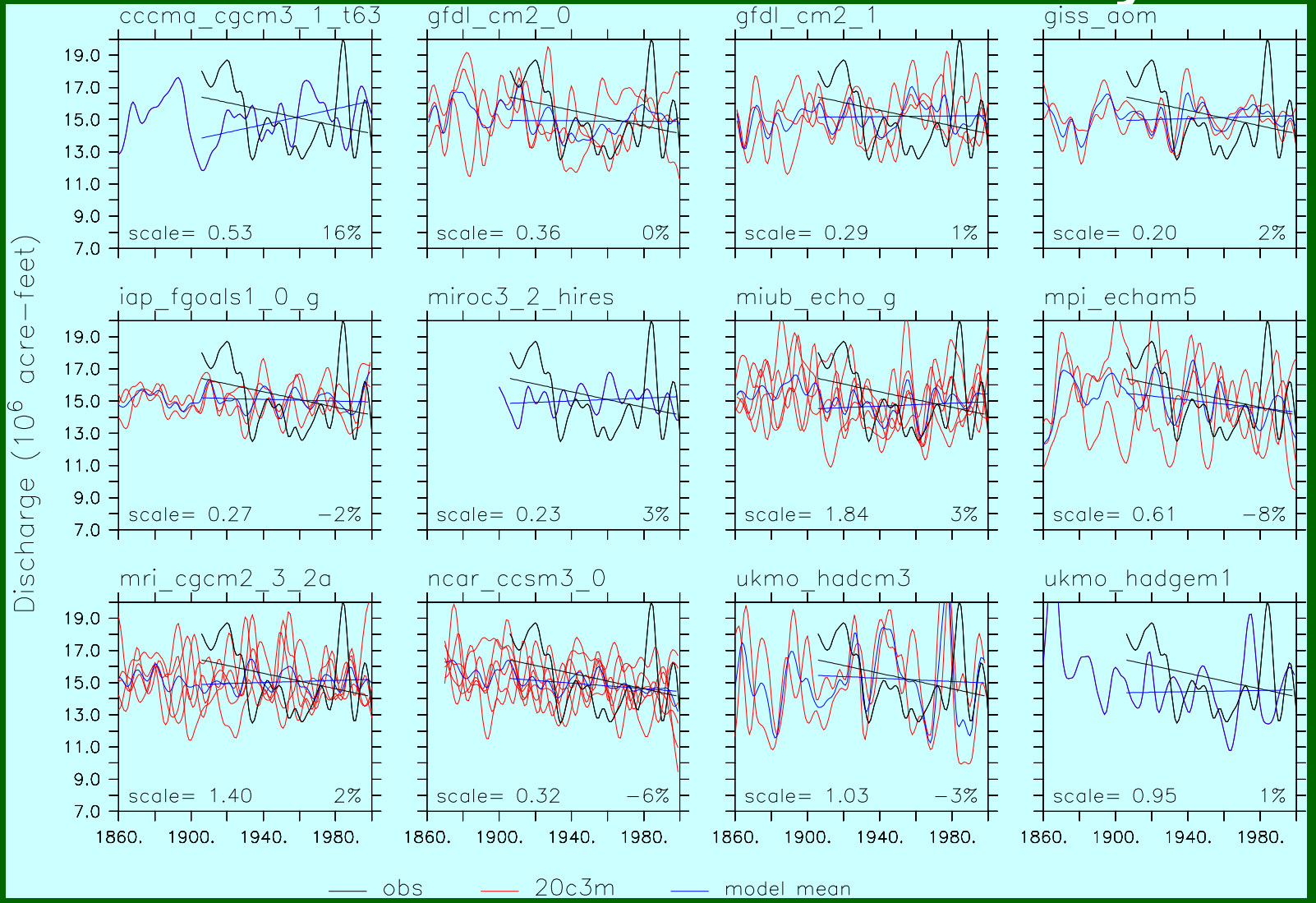
Colorado River at Lee's Ferry



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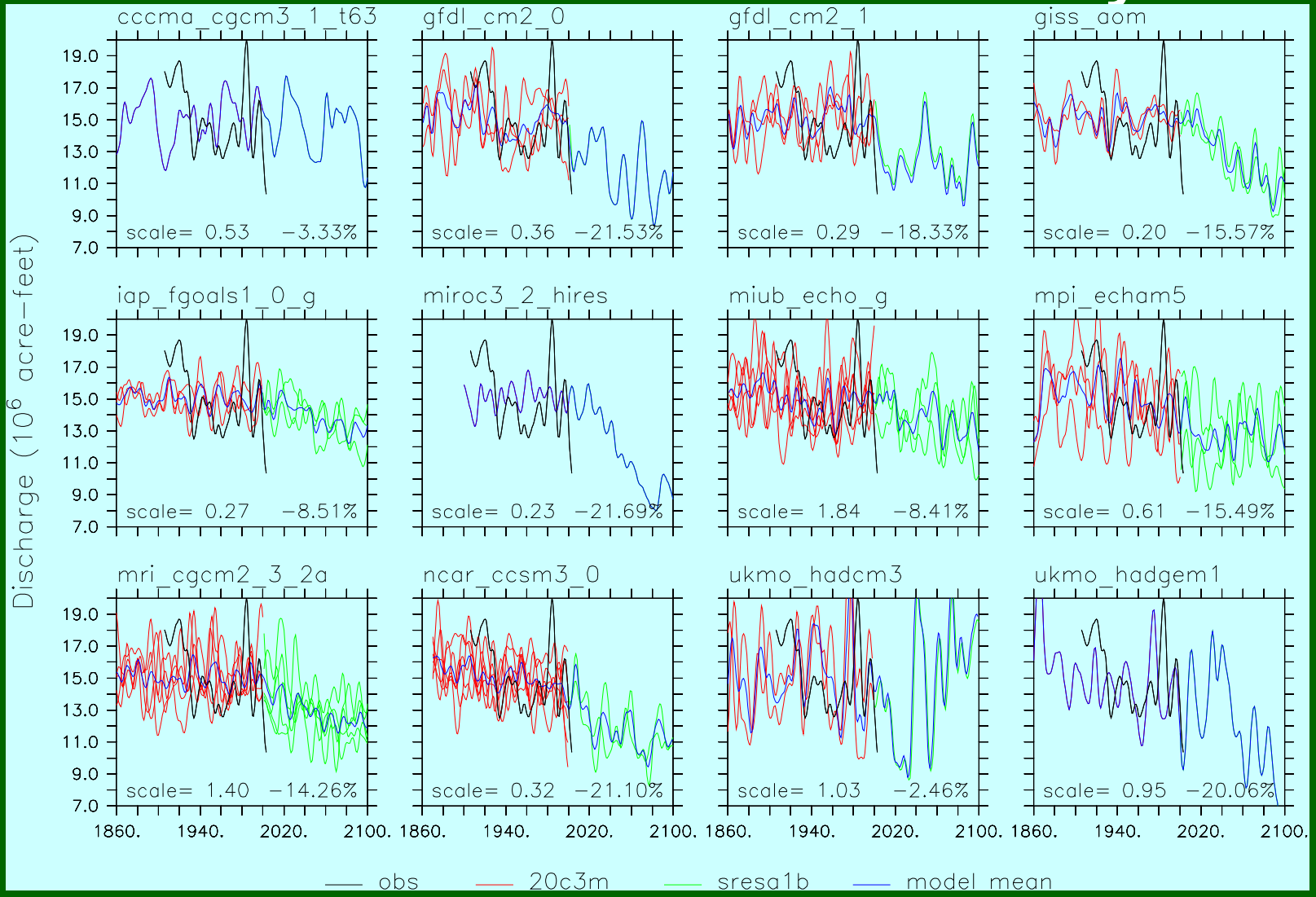
Model results are scaled to match adjusted flow record from Webb et al. (2005), which has linear slope of –16%/century.

Colorado River at Lee's Ferry



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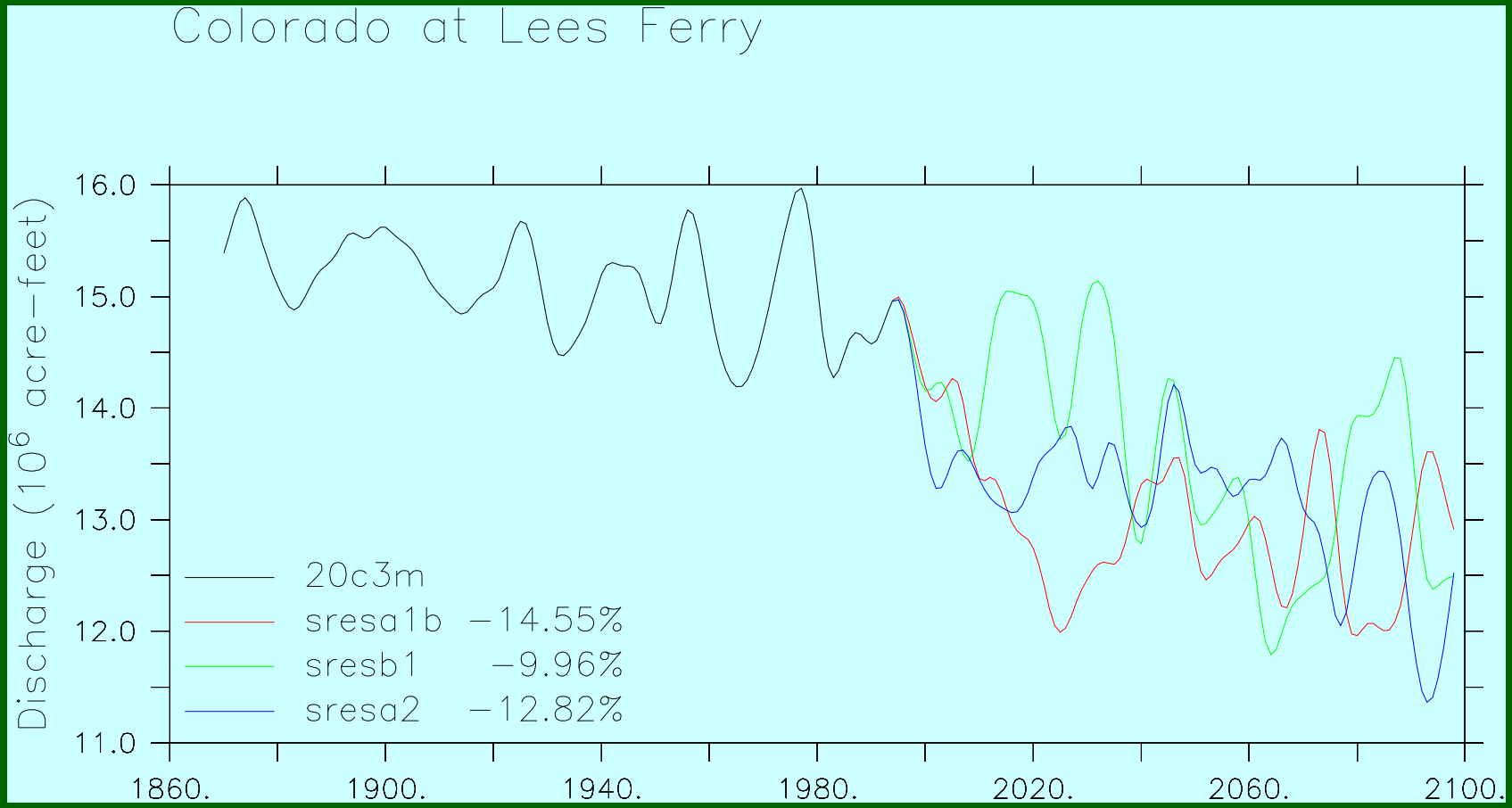
Colorado River at Lee's Ferry



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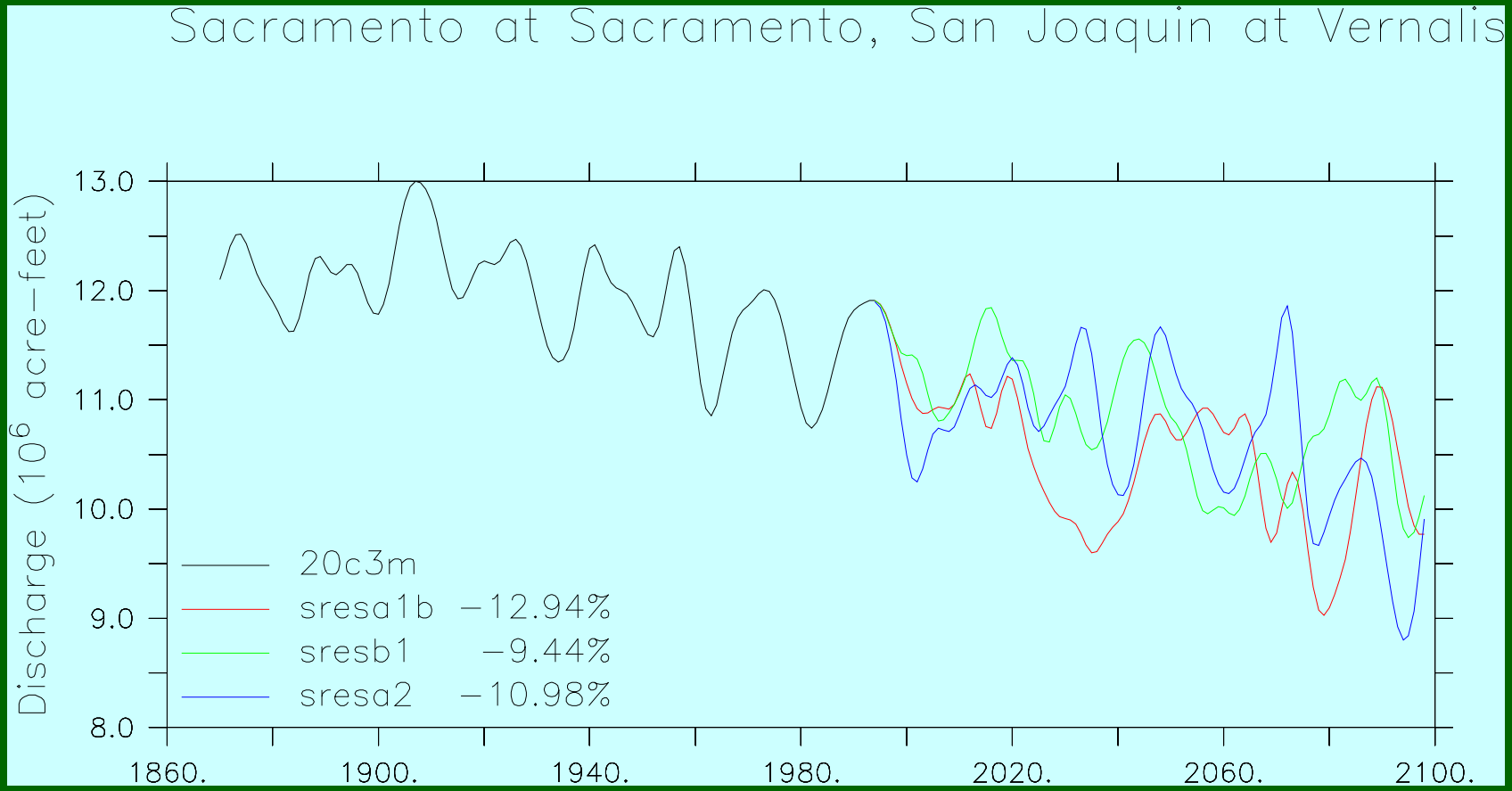
Combined SF Bay Inflows



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Concluding Comments

- Climate models have significant, though imperfect, skill in characterizing regional trends in mean annual streamflow.
- Climate models project substantial regional changes in mean annual streamflow for the 21st Century.

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